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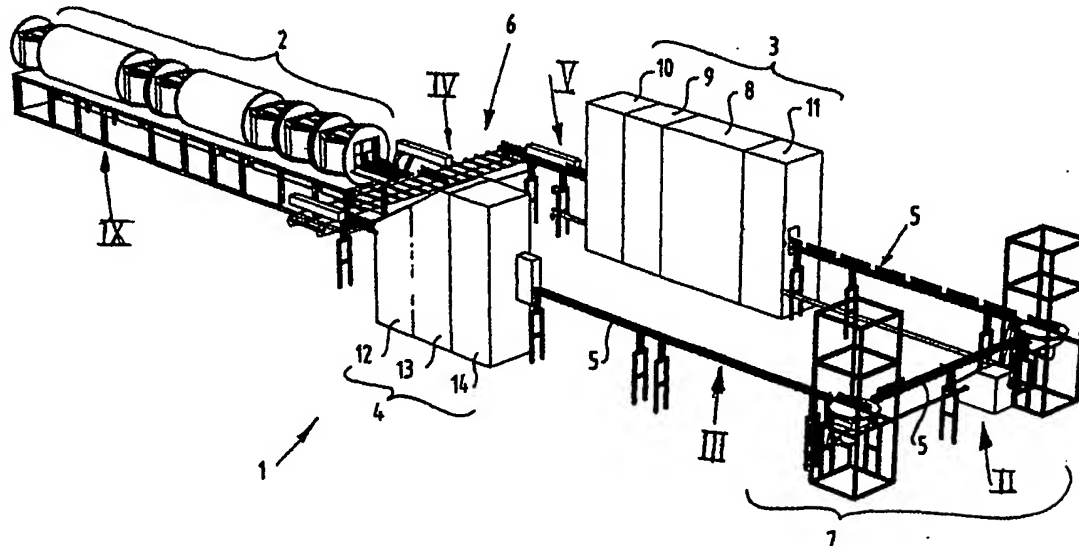
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## (57) Abstract

The invention relates to an apparatus (1) for applying at least one coating to objects by means of vapour deposition (PVD) under vacuum, comprising: a preprocessing device (3) for performing a preprocessing on the object; a PVD device (2) for coating an object under a vacuum; and a postprocessing device (4) for postprocessing the objects, wherein: the apparatus comprises a transport device (5) which extends through the preprocessing device, the PVD device and the postprocessing device, the transport device is adapted to transport objects arranged on carriers, and the PVD device is adapted for semi-continuous treatment of objects arranged on the carriers.

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**APPARATUS AND METHOD FOR COATING OBJECTS THROUGH PVD**

5           The present invention relates to an apparatus for coating objects by means of PVD (Physical Vapour Deposition), comprising:

- a preprocessing device for performing a preprocessing on the object;
- 10           - a PVD device for coating the object under an atmosphere differing from the ambient; and
- a postprocessing device for postprocessing the objects.

          Such apparatus are generally known. They are  
15 for instance used to apply a thin layer of metal on plastics to give the object the appearance of metal. Examples hereof are for instance caps for cosmetics bottles, prizes such as presented at sporting events, car components and the like.

20           According to the prior art the objects for processing are placed on racks and provided with a lacquer coating. This lacquer coating enhances adhesion between the plastic from which the object is made and the metal coating to be applied thereto. The lacquer coating  
25 moreover provides a smooth surface, so that the reflection of the metal to be coated thereon is improved.

          It is further pointed out that the pretreatment can also comprise a treatment prior to lacquering, such as a flame treatment. The surface properties of the  
30 plastic object are hereby changed so that the lacquer adheres better to the plastic.

          The objects for processing are subsequently placed in a vacuum vessel.

          A vacuum is then created in the vacuum vessel  
35 and, by means of evaporation of metal objects, metal vapour is introduced in the vacuum vessel which deposits on the lacquered components. This process is known as "Physical Vapour Deposition" (PVD).

After complete evaporation of the relevant element, air is again admitted into the vessel, whereafter the thus metallized objects on the racks can be removed.

5           The objects are thereafter subjected to a post-treatment, which is generally formed by a new lacquer treatment. It is pointed out here that the applied metal layer is extremely thin and is easily damaged. In order to protect this layer a protective lacquer coating is  
10 therefore applied. This lacquer coating further provides the option of changing the colour. In general use is made of aluminium as PVD material, wherein it is possible by colouring the lacquer to change the colour to for instance gold or copper colour.

15           A problem with this method generally used heretofore is that many operations must inevitably be performed manually, requiring much human labour. This is caused by the discontinuous character of the PVD process and by the relatively long drying time of the lacquers  
20 once they have been applied to the plastic objects. The work is moreover usually difficult.

          The object of the present invention is therefore to provide an apparatus with which metal coating with the associated preceding and following  
25 operations can take place as far as possible in automated manner.

          This object is achieved in that the apparatus comprises a transport device which extends through the preprocessing device, the PVD device and the  
30 postprocessing device; that the transport device is adapted to transport objects arranged on carriers and that the PVD device is adapted for semi-continuous treatment of objects arranged on the carriers.

          The semi-continuous character of the PVD device  
35 enables successive treatment of the carriers with a series of objects. Because the transport device is adapted for this purpose, and moreover extends through the preprocessing device and postprocessing device, it

becomes possible to treat the objects for vapour deposition without loading and unloading operations. This combination of measures thus enables the use of a certain degree of automation; only at the start do the objects  
5 have to be placed on the carriers, and after completion of the postprocessing they can be removed therefrom. Handling of the objects between the treatments, albeit placed on racks, is dispensed with.

According to a preferred embodiment the  
10 carriers are elongate and the transport device is adapted to move the carriers substantially in the longitudinal direction.

This configuration has the advantage that the objects arranged on the carriers are always readily  
15 accessible for the devices for applying lacquer and the like.

According to another preferred embodiment the PVD device is connected to the ambient by means of a single lock, the transport device extends through the  
20 lock and the lock is adapted to feed a carrier simultaneously into and out of the PVD device.

This provides the option of applying a single lock construction, these being generally expensive.

According to yet another preferred embodiment  
25 the transport device has a closed configuration and extends in two directions through the PVD device.

This also results in an attractive construction; when for instance further lock constructions are used, they can likewise be used in both  
30 directions, while the construction length of the apparatus can moreover be shortened by using it on two sides.

In addition, it is attractive to use buffers between the preprocessing device and the PVD device, and  
35 between the PVD device and the postprocessing device. These buffers have the function of compensating for the semi-continuity of the process performed in the PVD devices.

If the buffers are adapted to move the carriers in transverse direction, the buffers take up less space.

According to a particular preferred embodiment, the preprocessing device comprises a blower device for  
5 blowing dust from the objects for treating.

This blower device is preferably adapted to blow ionized air.

According to another preferred embodiment the preprocessing device comprises an application device for  
10 applying onto the objects for treating a lacquer which cures with UV radiation, as well as a UV radiation device.

The use of lacquer which cures with radiation enables shortening of the drying time, this being one of  
15 the most significant drawbacks of the prior art. The use of lacquer which cures with radiation considerably shortens the drying time, so that the objects thus provided with a lacquer coating can be subjected more rapidly to the following processing.

20 According to yet another attractive preferred embodiment, the preprocessing device comprises a surface processing device connected prior to the application device for processing the surface of the objects for treating.

25 This is understood to mean for instance a corona device. The properties of the surface of the objects for treating are herewith changed so as to improve adhesion with the lacquer.

The advantage of the lacquer which cures with  
30 radiation applies not only in the pretreatment but also in the post-treatment.

An attractive preferred embodiment further results when a loading/unloading station is placed between the postprocessing device and the preprocessing  
35 device for unloading processed objects and loading objects for processing.

This configuration has the advantage that loading and unloading, i.e. the major part of operations

to be performed by human intervention, take place within the same area. This not only has logistic advantages, but also advantages in the field of hygiene and working conditions.

5 Loading and unloading are understood to mean operations wherein the carriers remain on the transport path and the processed objects are exchanged for objects for processing, as well as operations wherein the carriers are removed from the transport path in their  
10 entirety and are re-placed on the transport path and wherein the actual loading and unloading of the carriers takes place at another location.

According to yet another preferred embodiment the carriers are provided with interchangeable object  
15 holders.

This measure provides the advantage that the carriers can be used for different types of object; only the object holders have to be exchanged. This is particularly important in respect of the cost of the  
20 carriers; these carriers after all comprise expensive components manufactured with great precision.

In order to expose the objects properly on all sides to the processes to be applied, it is advantageous when the object holders are placed on vertically  
25 extending shafts mounted rotatably in the carriers.

This advantage is further enhanced when toothed wheels are arranged on the shafts for driving the shafts in rotation.

Because application of the lacquer in  
30 particular usually involves waste, it is important for the toothed wheels to be protected against this. For this purpose they are preferably arranged under the top side of the carrier. This provides the option of arranging protective means, so that lacquer dripping from the  
35 objects cannot reach the toothed wheels.

According to another preferred embodiment the toothed wheels are let into openings arranged in the carrier and the toothed wheels protrude outside the side

walls of the carrier. This provides the possibility of providing the transport device with gear racks or chains for engaging in and rotating the toothed wheels during passage of the carriers, so that the shafts, and the  
5 objects placed thereon by means of the object holders, can thereby be rotated.

The present invention will be elucidated hereinbelow with reference to the annexed drawings, in which:

10 figure 1 shows a perspective schematic view of a complete apparatus according to the present invention;

figure 2 shows a perspective schematic view of the loading and unloading station of the apparatus shown in figure 1 as according to arrow II in figure 1;

15 figure 3 is a detail view as according to arrow III in figures 1 and 2;

figure 4 shows a perspective view of the buffer device according to the present invention as according to arrow IV in figure 1;

20 figure 5 is a perspective detail view as according to arrow V in figure 4;

figure 6 is a perspective detail view of figure 5;

figure 7 shows a perspective detail view as  
25 according to arrow VII in figure 4;

figure 8 shows a perspective detail view as according to arrow VIII in figure 4;

figure 9 shows a partly broken away perspective view of a vacuum evaporation chamber; and

30 figure 10 shows a perspective view of a carrier which is provided with diverse insert elements for carrying diverse objects for processing.

Figure 1 shows a metallizing apparatus designated in its entirety as 1. Broadly speaking, this  
35 metallizing apparatus is formed by a magnetron sputtering device 2, a preprocessing device 3 and a postprocessing device 4. Extending through each of these devices is a transport device 5. A shunting area 6 is arranged between



preprocessing device 3 and PVD device 2 and between PVD device 2 and postprocessing device 4.

This shunting area serves to compensate for timing differences between the continuously operating preprocessing device 3 and postprocessing device 4 and the semi-continuously operating PVD device 2. Transport device 5 is closed and extends in both directions through PVD device 2. Between postprocessing device 4 and preprocessing device 3 the transport device 5 extends through a loading and unloading zone 7.

This loading and unloading zone is further shown in figure 2. This shows that transport device 5 has a U-shape at this location. At the positions where transport device 5 forms an angle are arranged rotation devices 20, each comprising a rotating disc 21. By means of rotating discs 21 it is possible to rotate carrier 15 through an angle of  $90^\circ$ . In order to move carriers 15 onto rotating discs 21 use is made of the drive device which is integrated into transport device 5. In order to move the carriers off the turned rotating disc 21 onto the following part of transport device 5, use is made of a pushing element 22 drivable by a linear drive element 23 arranged above the rotating disc.

The objects 24 for processing are placed on carriers 15 on that part of the transport device 5 placed between the two rotation devices 20. This part forms the loading zone 7A.

The finished products 24 can be taken off the part of transport device 5 preceding rotation device 20. This is the unloading zone 7B.

Figure 2 further shows how a check gate 25 is placed after the second rotation device 20 for checking the presence of and the location in a plane perpendicular to the direction of movement of the objects for treating. The presence detection is important for controlling for instance the lacquer device, so as to prevent an excessive quantity of lacquer being wasted by spraying while no object is passing.

The location detection serves to prevent objects placed askew on the holders from disrupting the movement of the carriers, whereby objects could become jammed or fall off. This would result in stopping of the process, removal of the objects in question and restarting of the process.

The first gate 25 placed after the loading station therefore serves mainly to determine whether the objects are placed correctly. Such a gate is also placed before the vacuum device. In the vacuum device the position of the objects is after all critical, and space is limited, this being particularly important in the case of large objects. Furthermore, the location of the objects on the carrier may have been changed due to the action of the spraying device.

Figure 3 further shows the construction of transport device 5 at the location of unloading zone 7B.

Shown in figure 3 is that part of the transport device which functions as unloading station.

The transport device comprises two tubular profiles 26 which are provided at regular distances on their underside with bearing units 27, in which are mounted shafts 28. A support wheel 29 is arranged on each of the shafts 28. Further arranged are two U-shaped profiles 30 which are each fixed against tubular profiles 27. In one of the two U-shaped profiles 30 is arranged a drive chain 31, which is provided with catch elements 32 for moving the carriers 15 along. The chain is guided back again via the underside of the transport device. This transport device extends through the entire apparatus according to the invention.

Carriers 15 are each formed by a carrier body 36, in which are mounted vertically extending shafts 16. Carrier body 36 is provided with recesses 18 through which shafts 16 extend and wherein toothed wheels 17 are arranged on the shafts at the location of recesses 18. These toothed wheels 17 serve to drive the shafts in

rotation when for instance a gear rack or movable chain is arranged along the sides of profile 26.

Each of the shafts are provided on their top with a recess 33 on which extension shafts 34 can be placed. Product holders adapted to the product for processing, which will be described with reference to figure 10, can then be placed on top of extension shafts 34. It is pointed out here that it is possible to use extension shafts 34 of different heights, so that it is possible to adjust the height of the objects for processing on the carriers.

A part of the profile 30 can otherwise be folded down at the location of unloading station 7B, so that carriers 15 can be taken away.

Further shown in figure 4 is a buffer device 6 which provides the synchronization of the essentially continuously operating preprocessing and postprocessing device and the semi-continuously operating vacuum metallization device.

Buffer device 6 is formed essentially by a frame 35 on which are placed two shafts 37, one of which is drivable by means of a motor 38. A chain wheel 39 is placed on each of the shafts 37, wherein a chain 40 is trained around each pair of chain wheels 39. Supports 41 are arranged between the two chains 40 for transporting carriers 15.

Shaft 36 is herein set into intermittent rotation such that supports 41 move intermittently. During the standstill periods of these carriers, the carriers from UV radiation device 10 are loaded onto the support 41 placed in line with transport device 5, while the carrier then placed in front of the transport device of the vacuum metallization device is simultaneously pushed onto the transport device of the metallization device by means of a pushing device 42. A carrier coming from the metallization device is simultaneously pushed onto the relevant support 41 and a carrier placed in front of the transport device of the UV lacquer spraying

device 12 is pushed onto the relevant transport device. The device in question then moves one full stroke, whereafter this process is repeated.

Figure 5 shows how a pushing device 42 is arranged for pushing a carrier 15 onto the relevant support 41. This pushing device 42 is herein driven by a linear drive member 43.

This device further shows how the shafts 16 of carrier 15 can be driven in rotation by means of toothed wheels 17, this independently of the linear movement of carrier 15. Use is made for this purpose of a chain 46, a part of which is arranged parallel to the direction of movement of carrier 15 and which can be driven independently of the transport movement. It will be apparent that it is possible to make use instead of for instance gear racks. These are then arranged fixedly so that the rotation movement is in fact coupled to the transport movement.

Various aspects are shown in more detail in figure 6.

Figure 7 shows in more detail the mechanism with which the movements of supports 41 to the transport device 5 within the vacuum metallization device are executed, and vice versa.

This shows the construction of the linear drive device 43 which is connected by means of a frame 47 to a pushing device 44.

Figure 8 shows in more detail a part of the drive device for transport of carriers 15 inside the vacuum metallization device. The relevant elements are herein mounted on a plate 50, on which are arranged two beams 51 on which guide wheels with guide shafts 52 are mounted. In the middle of each of these beams 51 a guide wheel 52 is further arranged on the other side of the path of the carrier. Finally, support wheels 53 are arranged.

Drive wheels 55 are also arranged for driving the carrier 15. Drive wheels 54 are herein driven by

means of belts 55. Both belts 55 are trained round a wheel 56 which is driven by a motor mounted beneath the plate. This drawing also shows that a check gate device is again placed in order to determine whether all objects  
5 are present on the carrier.

Figure 9 shows the construction of the vacuum metallization chamber 4, which otherwise forms the subject-matter of the European patent application 98.203444.9. Here also the same drive device is used.  
10 This is further of importance in that plates 57 are arranged to protect the transport device against precipitation of metal. Such plates are otherwise also arranged in the paint spraying devices.

This figure further shows how the actual  
15 targets 58 of the magnetron sputtering device are arranged at two different levels. In combination with the different heights of the extension shafts it is thus possible to determine the height and direction of the metallization process.

20 In the present construction the objects for processing pass twice through the magnetron sputtering device, wherein only one of the two passages is effective. The active half of the device is separated from the non-active half of the device by a partition  
25 wall 59 of a material on which the sputtered vapour will deposit but which can be removed easily.

Finally, figure 10 shows the construction of product carriers 15. The product carriers are placed on top of the extension shafts to carry the products for  
30 processing. In the present case the product carriers are formed by a piece of threaded end which can be placed on the extension shaft, wherein discs provided with internal thread can be placed on the threaded ends, the form and position of which discs can be adapted to the relevant  
35 products.

**CLAIMS**

1. Apparatus for applying at least one coating  
5 to objects by means of vapour deposition (PVD) under vacuum, comprising:

- a preprocessing device for performing a preprocessing on the object;
- a PVD device for coating the object under a  
10 vacuum; and
- a postprocessing device for postprocessing the objects,

**characterized in that**

- the apparatus comprises a transport device  
15 which extends through the preprocessing device, the PVD device and the postprocessing device,
- the transport device is adapted to transport objects arranged on carriers, and
- the PVD device is adapted for semi-continuous  
20 treatment of objects arranged on the carriers.

2. Apparatus as claimed in claim 1,  
**characterized in that** the carriers are elongate and the transport device is adapted to move the carriers substantially in the longitudinal direction.

25 3. Apparatus as claimed in claim 2,  
**characterized in that** the PVD device is connected to the ambient by means of a single lock, the transport device extends through the lock and the lock is adapted to feed a carrier simultaneously into and out of the PVD device.

30 4. Apparatus as claimed in claim 3,  
**characterized in that** the transport device has a closed configuration and extends in two directions through the PVD device.

5. Apparatus as claimed in claim 4,  
35 **characterized in that** a buffer for the carriers is arranged between the preprocessing device and the PVD device.

6. Apparatus as claimed in claim 5,  
characterized in that a buffer for the carriers is  
arranged between the PVD device and the postprocessing  
device.

5 7. Apparatus as claimed in claim 5 or 6,  
characterized in that the buffers are adapted to move the  
carriers in transverse direction.

8. Apparatus as claimed in any of the foregoing  
claims, characterized in that the preprocessing device  
10 comprises a blower device for blowing dust from the  
objects for treating.

9. Apparatus as claimed in any of the foregoing  
claims, characterized in that the preprocessing device  
comprises an application device for applying onto the  
15 objects for treating a lacquer which cures with  
radiation, for instance UV or IR radiation, and a device  
for irradiating the lacquered objects with the relevant  
radiation.

10. Apparatus as claimed in claim 9,  
20 characterized in that the preprocessing device comprises  
a surface processing device connected prior to the  
application device for processing the surface of the  
objects for treating.

11. Apparatus as claimed in any of the  
25 foregoing claims, characterized in that the  
postprocessing device comprises an application device for  
applying onto the objects for treating a lacquer which  
cures with radiation, for instance UV radiation, and a  
device for irradiating the lacquered objects with the  
30 relevant radiation.

12. Apparatus as claimed in any of the  
foregoing claims, characterized in that a  
loading/unloading station is placed between the  
postprocessing device and the preprocessing device for  
35 unloading processed objects and loading objects for  
processing.

13. Carrier for use in an apparatus as claimed  
in any of the foregoing claims, characterized in that the

carriers are provided with interchangeable object holders.

14. Carrier as claimed in claim 13,  
**characterized in that** the object holders are placed on  
5 vertically extending shafts mounted rotatably in the  
carriers.

15. Carrier as claimed in claim 14,  
**characterized in that** toothed wheels are arranged on the  
shafts for driving the shafts in rotation.

10 16. Carrier as claimed in claim 15,  
**characterized in that** the toothed wheels are arranged  
under the top side of the carrier.

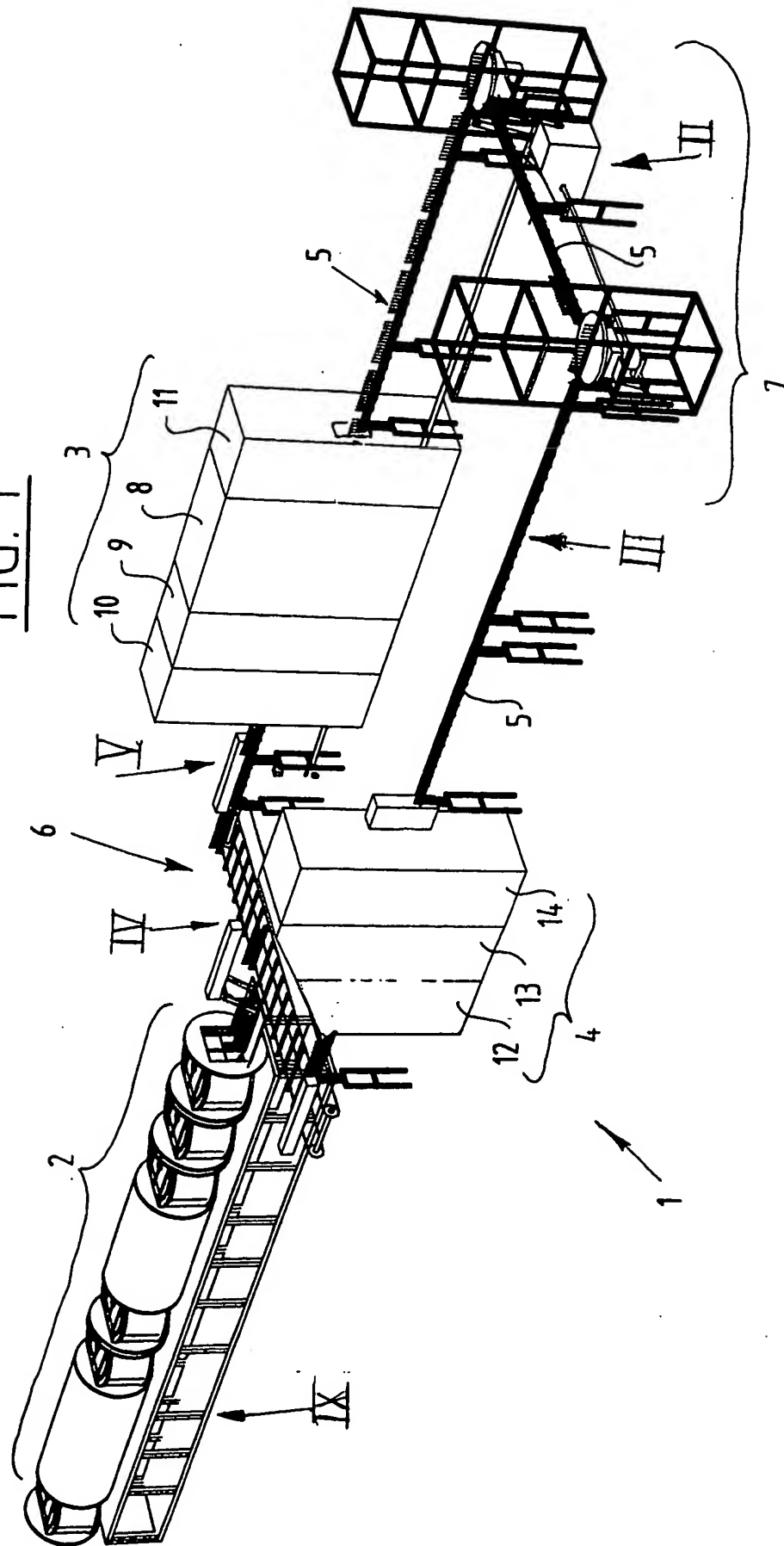
17. Carrier as claimed in claim 16,  
**characterized in that** the toothed wheels are let into  
15 openings arranged in the carrier and the toothed wheels  
protrude outside the side walls of the carrier.

18. Apparatus as claimed in any of the claims  
1-12, suitable for carriers as claimed in any of the  
claims 13-17, **characterized in that** the apparatus is  
20 provided with cams for engaging in and rotating the  
toothed wheels during passage of the carriers.

19. Apparatus as claimed in claim 18,  
**characterized in that** the cams form part of a drivable  
chain for causing the shafts to rotate independently of  
25 the linear movement of the carrier.

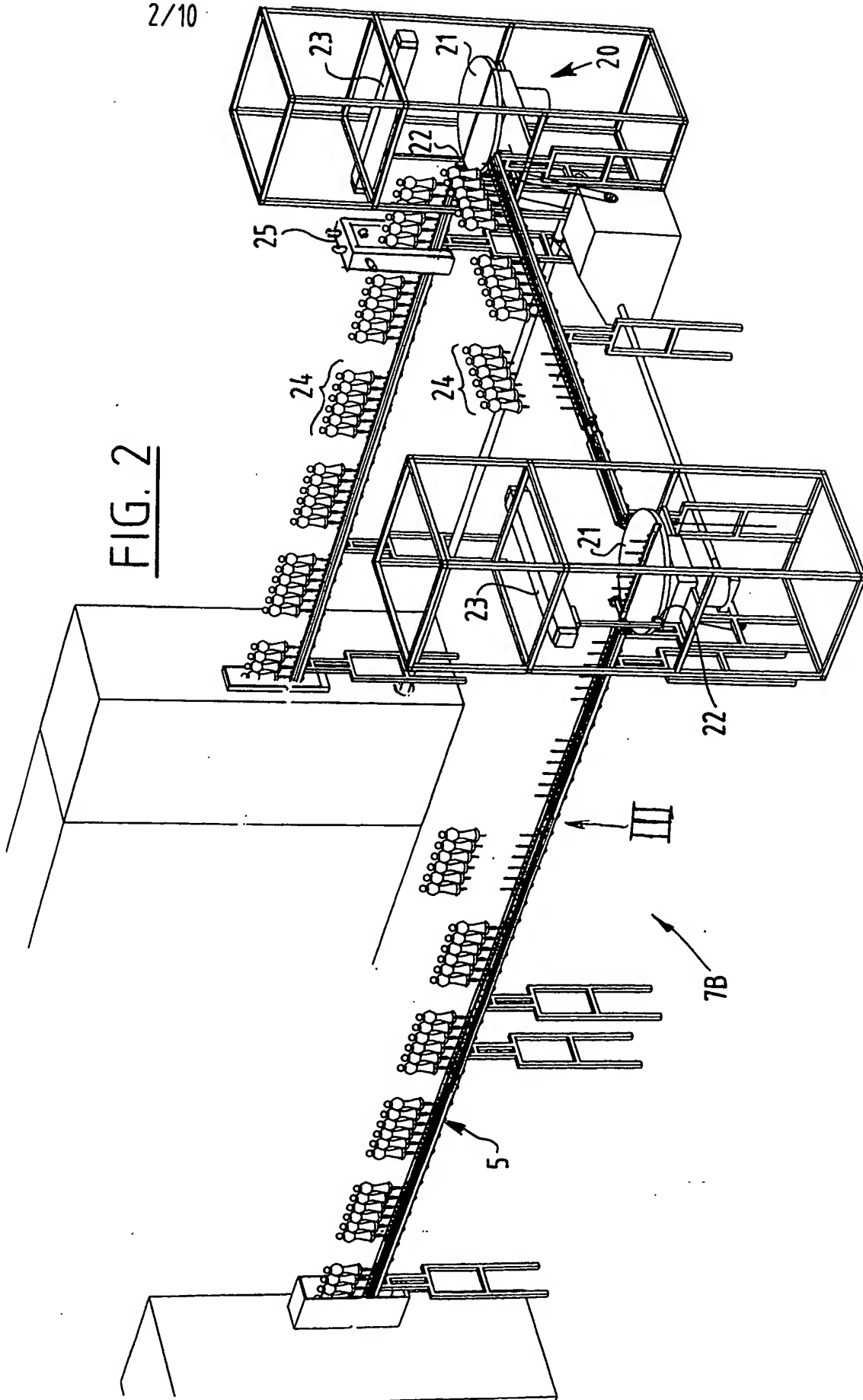


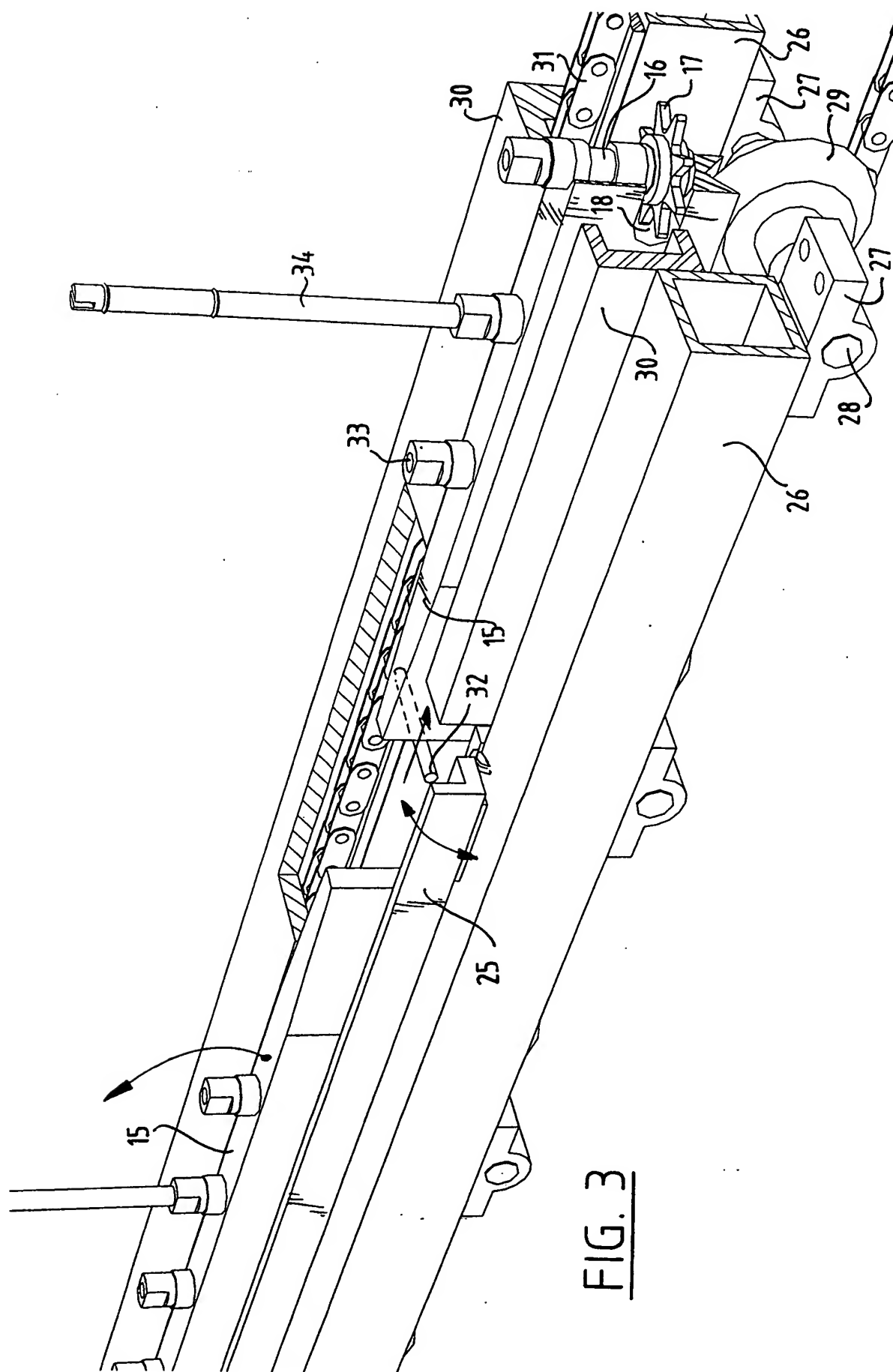
FIG. 1

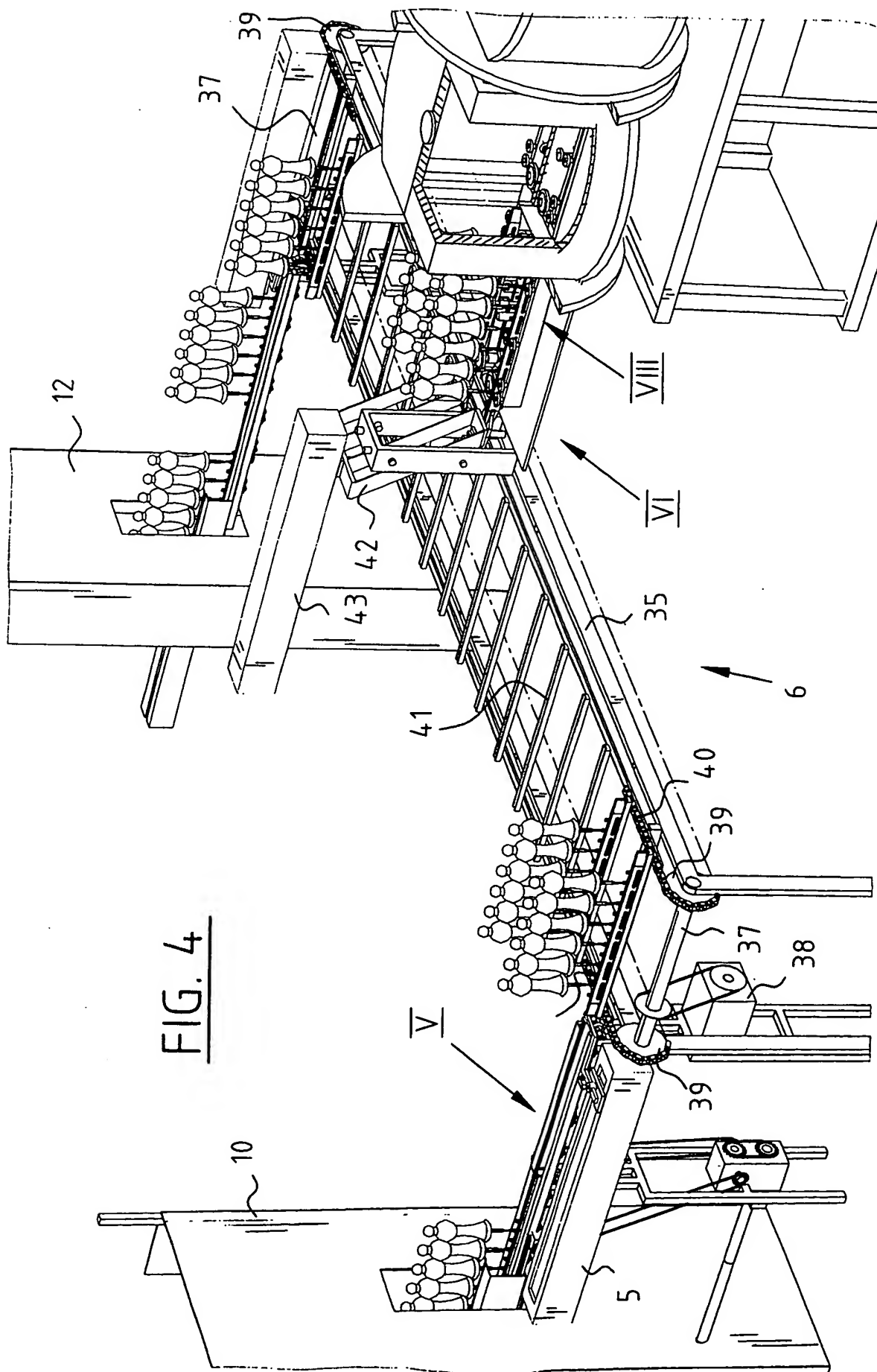


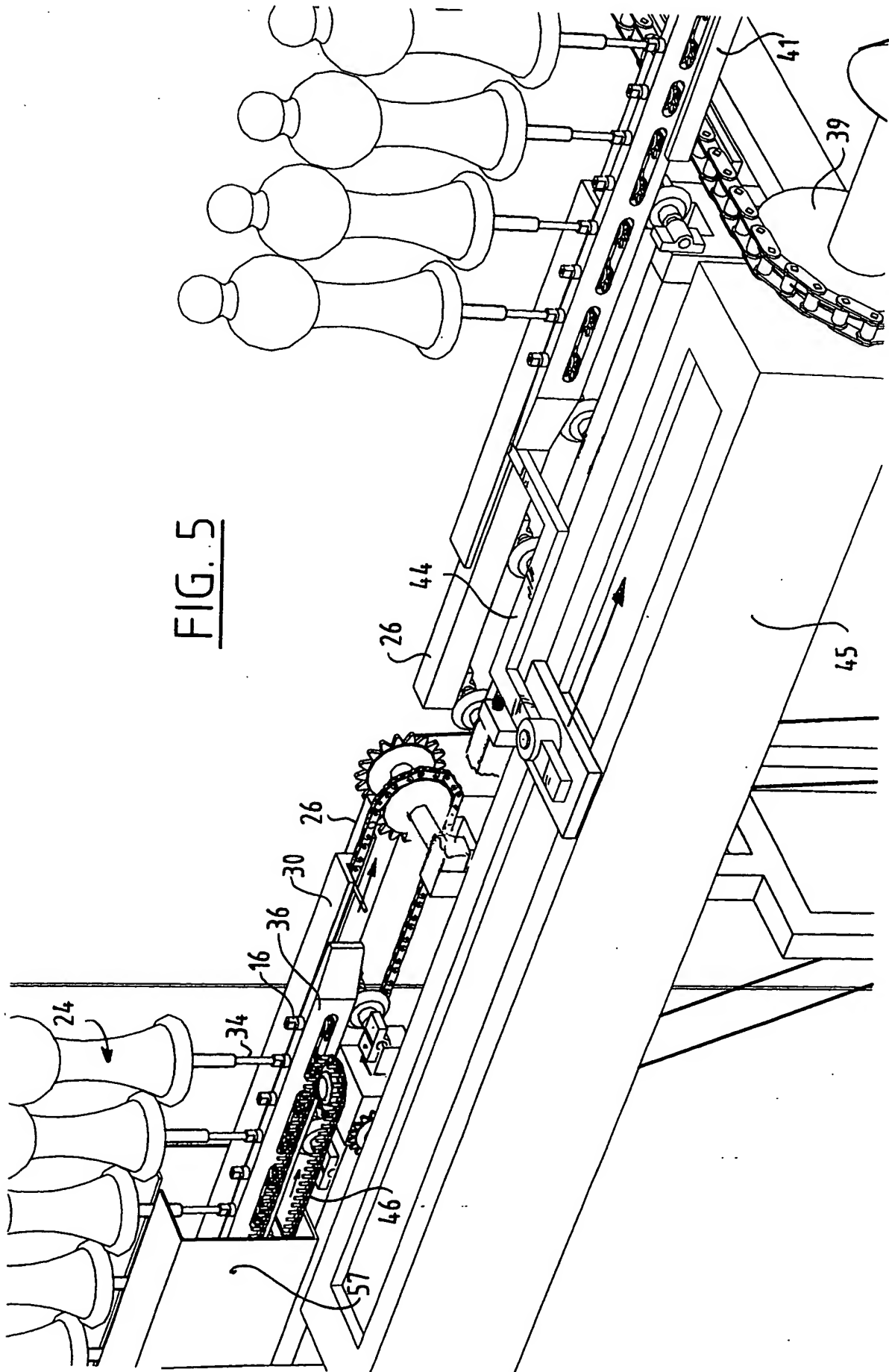
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FIG. 2

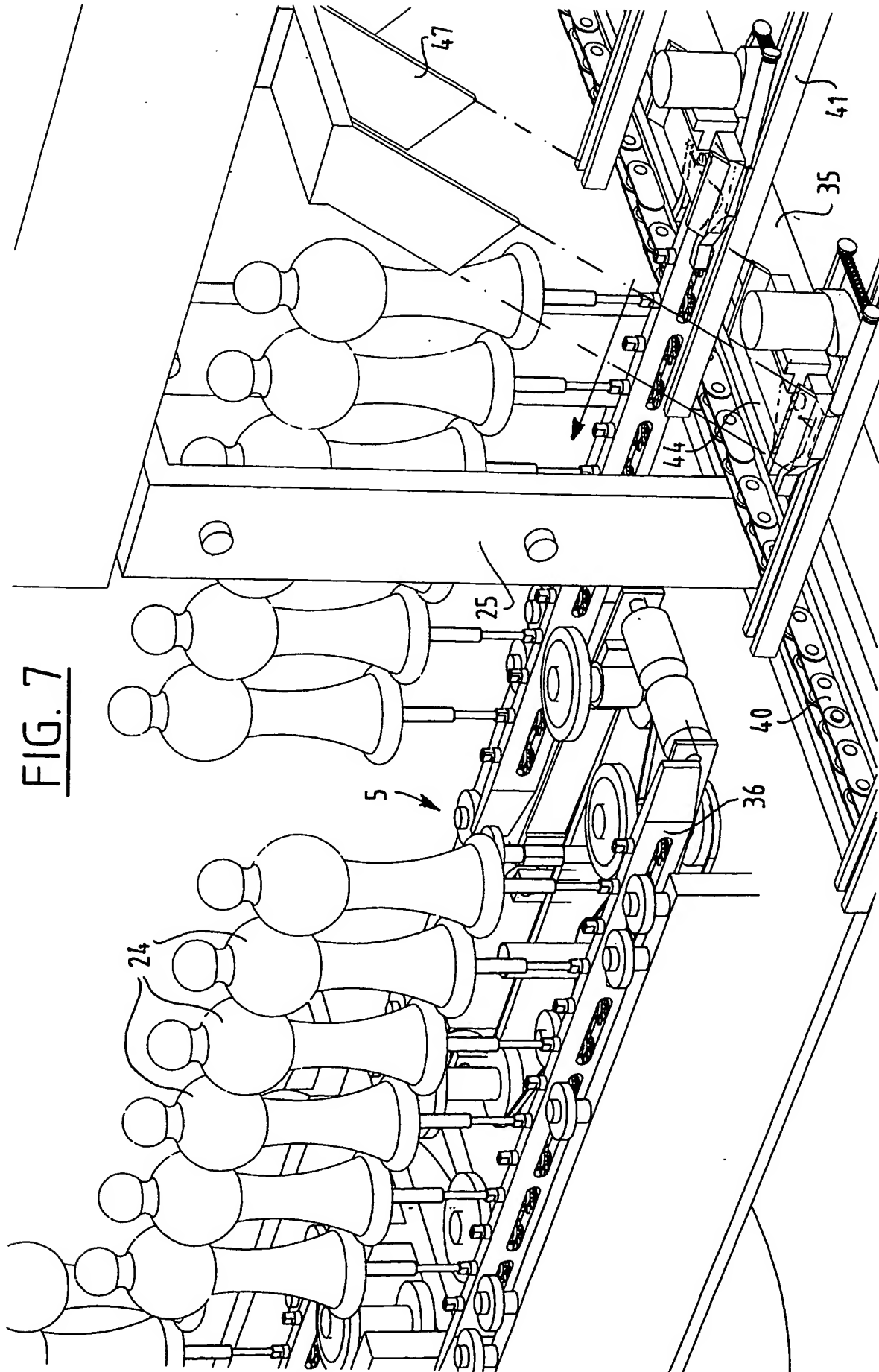












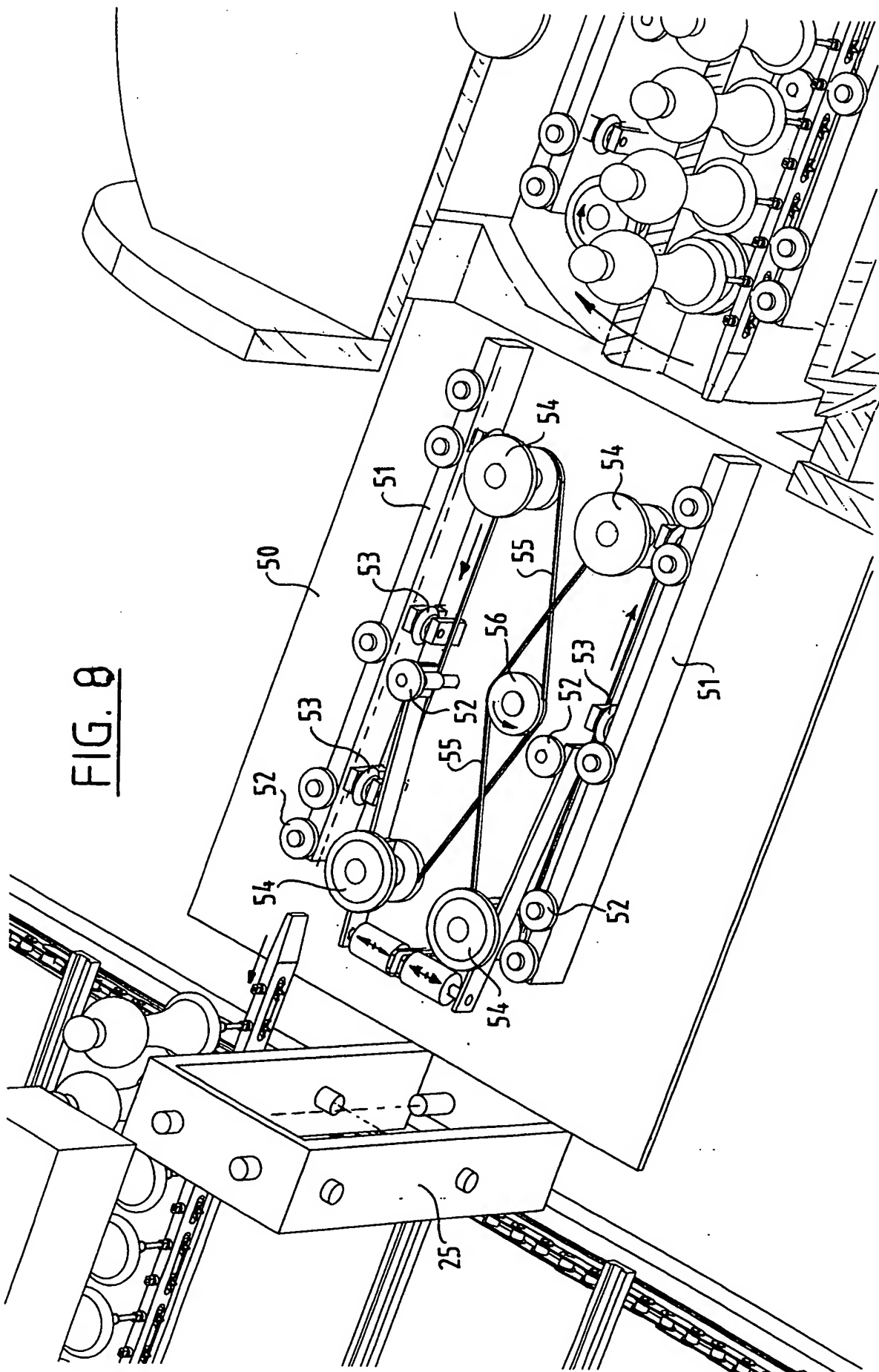
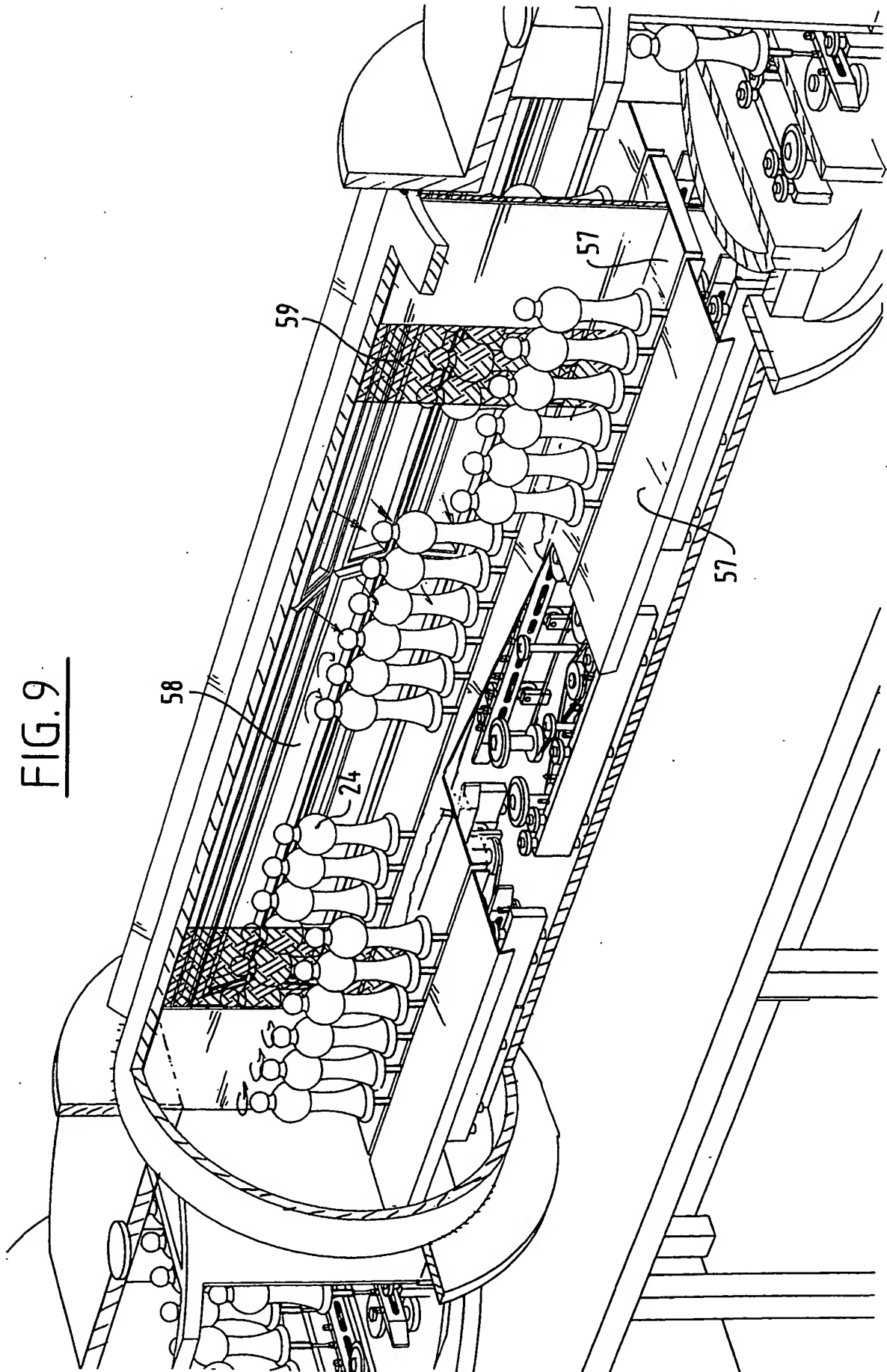
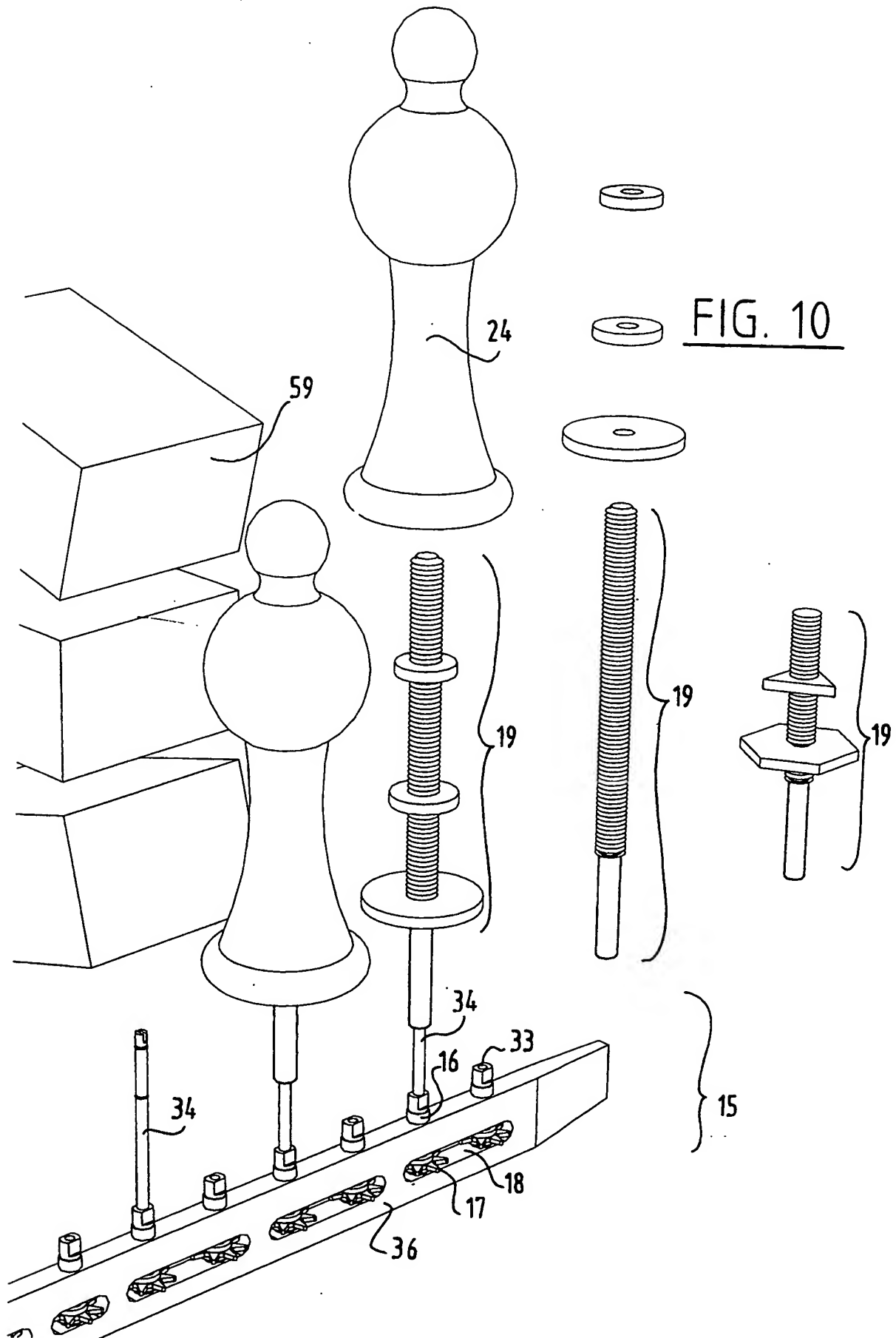




FIG. 9





# INTERNATIONAL SEARCH REPORT

International Application No

PCT/NL 99/00689

## A. CLASSIFICATION OF SUBJECT MATTER

IPC 7 C23C14/56 C23C14/50 B65G35/06 B65G17/00 B65G47/244  
B05D5/06

According to International Patent Classification (IPC) or to both national classification and IPC

## B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC 7 B05D C23C B65G

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

## C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
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Y	page 9, line 4 -page 10, line 2	14,15
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Y	US 4 637 342 A (KAMIYA OSAMU ET AL) 20 January 1987 (1987-01-20) column 3, line 20 -column 5, line 14	1,3
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Date of the actual completion of the international search

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## INTERNATIONAL SEARCH REPORT

International Application No

PCT/NL 99/00689

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